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PROVIDENCE–PAWTUCKET, NEW BEDFORD, FALL RIVER AIR POLLUTANT EMISSION INVENTORY

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A rapid survey was made to estimate total emissions of oxides of sulfur, oxides of nitrogen, hydrocarbons, carbon monoxide and particulate matter. The emissions of these pollutants are delineated with respect to source type, season of the year as well as their geographical distribution within the area. The study area is divided into grid zones that serve as a basis for locating sources and reporting their emissions. The emissions are expressed in terms of tons per average annual, summer and winter day. The emission estimates should be considered as showing the levels and conditions during 1967. The study area included three Standard Metropolitan Statistical Areas (Providence-Pawtucket, Fall River, and New Bedford) with a 1967 population of about 1.2 million people and some 1,000 square miles. Information was gathered on three types of area sources and over one hundred large industries and fuel users, of which about 45 were considered point sources. More than 700,000 tons of the five major pollutants are emitted annually. For each pollutant, a summary of the 1967 emissions as tabulated for each of these source categories: transportation (road vehicle, evaporation, other); combustion of fuels from stationary source (industrial, steam-electric, residential, other); refuse disposal (incineration, open burning); and industrial process emissions.

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Providence-Pawtucket, New Bedford, Fall River Air Pollutant Emission Inventory

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PUBLIC HEALTH SERVICE
Consumer Protection and Environmental Health Service
National Air Pollution Control Administration
Air Quality and Emission Data Division
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PREFACE

This report which presents the emission inventory of the Providence, Fall River and New Bedford area is another in a series of studies outlining the sources and emissions of air pollutants for major metropolitan areas of the country. These reports provide estimates of total emissions of oxides of sulfur, oxides of nitrogen, hydrocarbons, carbon monoxide and particulate matter. The emissions of these pollutants are delineated with respect to source type, season of the year as well as their geographical distribution within the area. These surveys are intended to determine the present level of emissions and the status of their control.

The general procedure of these surveys are based on the rapid survey technique.[1] The study area is divided into grid zones that serve as a basis for locating sources and reporting their emissions. All sources of pollution are classified into two general groups, i.e., point sources and area sources. All sources that emit large quantities of air pollutants are considered individually and located specially within the area. This group which generally contains about fifty to one hundred sources typically includes large industries, power plants, and refuse burning facilities. The remaining sources are considered collectively as area sources and their emissions are reported as totals for grid zones. This group includes motor vehicles, home heating, small industries, on-site refuse, etc. The emissions in both cases are expressed in terms of tons per average annual, summer and winter day.

Emissions for the most part, are estimated using various emission factors that are related to these. This means that information and data are collected on fuel consumption and refuse burning rates, vehicle-miles and gasoline consumption as well as various production data. These

are then translated into emission estimates by use of average emission factors. These factors, for the most part, represent average emission rates for a particular industry or fuel type. Because of the inherent differences in type of equipment, operating rates, control equipment, and efficiency of operation among the plants and fuel users within a given category, the application of the emission factors to any individual plant or even a smaller number of similiar plants or processes may result in a discrepancy between the actual and estimated emissions. However, the estimates of total pollutants from all sources in the study area should be fairly accurate.

INTRODUCTION

The information and data presented in this report were gathered in cooperation with the Massachusetts Health Department and the Rhode Island Health Department during the survey conducted in late October, 1968. The data obtained in this study is for the most part representative of 1967 and emission estimates presented herein should be considered as showing the levels and conditions during 1967.

For purposes of this survey a Study Area consisting of a portion of Massachusetts and Rhode Island was selected. The Study Area includes three Standard Metropolitan Statistical Areas (Providence-Pawtucket, Fall River, and New Bedford). A 1967 population of about 1.2 million people and some 1,000 square miles are included in the Study Area.

The Study Area was subdivided into 62 grids made up of two sizes: 25 square kilometer grids in the heavily populated and industrialized areas and 100 square kilometer grids in the more rural sections. Using this grid system, information was gathered on three types of areasources and over one hundred large industries and fuel users of which about 45 are being considered point sources in this survey.

Figure 1. Providence-Pawtucket, Fall River and New Bedford Study Area.

SUMMARY OF EMISSIONS

Over an estimated 700,000 tons of the five major pollutants are emitted annually in the Study Area. Breakdowns of this total with respect to specific pollutants as well as the type of sources emitting the pollutants are given in Table 1 and briefly summarized below.

Pollutant Type

Oxides of Sulfur:	Total tons per year	117,800
	Electric Generation	56%
	Residential Fuel Use	21%
	Industrial Fuel Use	16%
	Commercial Fuel Use	4%
	Other	3%
Particulates:	Total Tons Per Year	22,600
	Electric Generation	47%
	Open Burning	15%
	Road Vehicles	11%
	Industrial Fuel Use	9%
	Incineration	8%
	Industrial Process	5%
	Other	5%
Carbon Monoxide:	Total Tons Per Year	435,400
	Road Vehicles	93%
	Open Burning	4%
	Other	3%

Hydrocarbons:	Total Tons Per Year	54,300
	Road Vehicles	56%
	Evaporation	37%
	Balance of Transportation	3%
	Open Burning	2%
	Other	2%
Oxides of Nitrogen:	Total Tons Per Year	64,200
	Electric Generation	49%
	Road Vehicles	33%
	Industrial Fuel Use	9%
	Open Burning	4%
	Other	5%

Emissions by Point Sources

Oxides of Sulfur	81,500 T/Year
Particulates	13,500 T/Year
Carbon Monoxides	8,200 T/Year
Hydrocarbons	2,200 T/Year
Oxides of Sulfur	32,700 T/Year

TABLE 1 SUMMARY OF AIR POLLUTANT EMISSIONS IN THE PROVIDENCE STUDY AREA, 1967 (TONS/YEAR)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxides	Hydrocarbons	Nitrogen Oxides
Transportation	2,450	2,800	415,500	51,900	22,100
Road Vehicle	1,650	2,600	407,900	30,400	21,500
Evaporation	---	---	---	19,900	---
Other	800	200	7,600	1,600	600
Combustion of Fuels From Stationary Source	115,100	13,500	700	1,200	39,500
Industrial	19,200	2,100	100	100	5,500
Steam-Electric	66,100	10,600	400	500	31,500
Residential	24,900	600	200	600	1,200
Other	4,900	200	Neg.	Neg.	1,300
Refuse Disposal	200	5,200	19,200	1,200	2,600
Incineration	200	1,800	1,000	100	250
Open Burning	Neg.	3,400	18,200	1,100	2,350
Industrial Process Emissions	50	1,100	Neg.	Neg.	Neg.
Grand Total	117,800	22,600	435,400	54,300	64,200

STUDY AREA

As shown in Figure 1, the Study Area lies around Narragansett Bay and along Rhode Island Sound. There are 48 cities and towns in the Study Area. Twenty-eight are in Rhode Island while the remainder are situated in Massachusetts. The total area of this region is about 1,000 square miles of which approximately 270 square miles can be considered urban. Included in this urban portion are the cities of East Providence, Pawtucket, Warwick, Fall River, North Providence, Providence and New Bedford which collectively have some 600,000 inhabitants. The 1960 and 1967 population of each of the forty-eight cities and towns are shown in Table 2. Camparison of the two populations shows an average increase of 7.0 percent for the Study Area as compared to an increase of 10.9 percent for the United States during the same period.

The major manufacturing industries of the Area are those concerned with textile products and metal products. The number of establishments by industrial category are summarized for 1960 in Table 3.

The proximity of the Narragansett Bay and the Atlantic Ocean plays an important part in determining the climate for Providence and vicinity. In winter, the temperatures are modified considerably, and many of the storms drop their precipitation in the form of rain rather than snow. In summer, the days are often cooled by seabreezes

TABLE 2 POPULATION FIGURES FOR PROVIDENCE-PAWTUCKET
FALL RIVER, AND NEW BEDFORD SMSA'S

	1960	1967	Percent Increase
Providence Pawtucket SMSA	821,101	887,230	8
Rhode Island Portion	731,146	777,020	6
Barrington	13,826	16,530	19
Bristol	14,570	15,890	9
Burrilliville	9,119	9,790	7
Central Falls	19,858	18,900	-5
Coventry	15,432	17,820	15
Cranston	66,766	72,700	8
Cumberland	18,792	24,100	28
East Greenwich	6,100	8,300	- 36
East Providence	41,955	45,300	7
Jamestown	2,267	2,590	14
Johnston	17,160	19,750	15
Lincoln	13,551	14,750	8
Narragansett	3,444	5,100	48
North Kingstown	18,977	23,300	23
North Providence	18,220	21,400	17
North Smithfield	7,632	8,800	15
Pawtucket	81,001	78,300	-3
Providence	207,498	189,000	-9
Smithfield	9,442	12,150	29
Warren	8,750	9,860	13
Warwick	68,504	78,500	15
West Warwick	21,414	22,140	3
Woonsocket	47,080	47,300	1
Massachusetts Portion	89,743	110,210	23

TABLE 2 POPULATION FIGURES FOR PROVIDENCE-PAWTUCKET
FALL RIVER, AND NEW BEDFORD SMSA'S

	1960	1967	Percent Increase
Attleboro	27,118	29,110	7
Bellingham	6,774	12,200	80
Blackstone	5,130	6,410	25
Franklin	10,530	16,400	56
Millville	1,567	1,730	10
North Attleborough	14,777	16,000	8
Plainville	3,810	4,480	18
Rehoboth	4,953	5,700	15
Seekonk	8,399	10,500	25
Wrentham	6,685	7,680.	15
Fall River SMSA	138,156	151,780	10
Massachusetts Portion	128,695	140,650	9
Fall River	99,942	103,000	3
Somerset	12,196	16,350	34
Swansea	9,916	12,500	26
Westport	6,641	8,800	33
Rhode Island Portion	9,461	11,130	18
Tivertown	9,461	11,130	18
New Bedford SMSA	143,176	148,480	4
Acushnett	5,755	7,130	24
Dartmouth	14,607	17,600	20
Fairhaven	14,339	16,300	14

TABLE 2 POPULATION FIGURES FOR PROVIDENCE-PAWTUCKET
FALL RIVER, AND NEW BEDFORD SMSA'S

	1960	1967	Percent Increase
New Bedford	102,477	99,500	-3
Marion	2,881	3,630	26
Mattapoisett	3,117	4,320	39
Extra Rhode Island Towns			
Jamestown	2,267	2,600	15
Middletown	12,675	19,790	56
Newport	47,049	36,300	- 23
Portsmouth	8,251	10,780	31
Study Area Totals	1,172,675	1,254,620	7

TABLE 3 NUMBER OF ESTABLISHMENTS IN THE PROVIDENCE, NEW BEDFORD & FALL RIVER SMSA'S (1960)

	Providence	New Bedford	Fall River
Food Products	52	14	14
Textile & Leather Products	236	89	139
Paper & Printing	68	5	12
Chemicals & Petroleum	67	4	9
Lumber and Wood Products	14	2	2
Stone & Clay Products	5	1	2
Electrical Machinery	80	11	6
Transportation	13	7	1
Metal Products	139	10	8
Miscellaneous	262	5	2

GRID COORDINATE SYSTEM

Grid coordinates based on the Universal Transverse Mecator System were used in this study to show the geographical distribution of sources and emissions. As shown in Figure 2, the entire Study Area was divided into 62 grids of 2 different sizes--25 square kilometer, and 100 square kilometer.

Different size grids are used to limit the number of grid zones and yet allow a satisfactory definition of geographical gradation of emissions in areas where the majority of pollution occurs. For this, reason, the 25 square kilometer grids zones were placed in downtown areas, where the density of emissions changes abruptly within short distances. In areas primarily rural in nature, the use of small zones was not as important.

As illustrated in Figure 2, each grid line is identified by a coordinate number. The north-south and east-west coordinates are expressed in meters. The point sources are identified by the X-Y coordinates to the nearest 100 meters. The grids are identified by the X-Y coordinates of the geographical center of the grid.

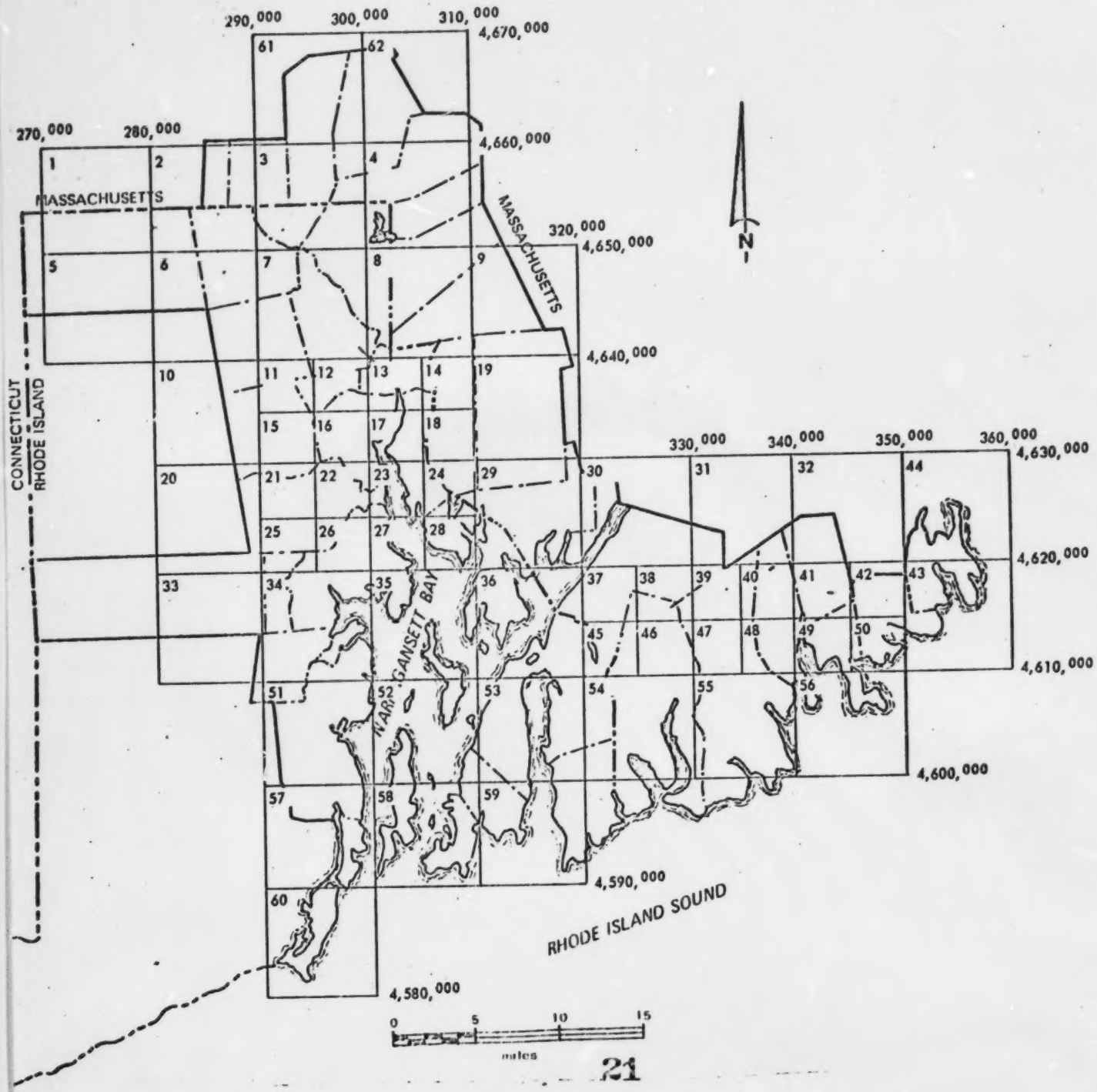

Figure 2. Grid system of Providence Study Area.

DISCUSSION OF RESULTS

All sources of air pollution considered in this survey fall into one of the following four categories:

1. Fuel consumption by stationary sources
2. Transportation sources
3. Refuse disposal
4. Industrial process losses

Each of these categories are dealt with individually in this section and in the subsequent section where data sources are given and techniques of calculation are discussed. In addition, the emissions from the point sources are compared with total area source emissions.

It is important to note that the estimates presented herein and especially in the process loss category are, in most cases, partial totals. This stems from the inavailability of emission factors as well as appropriate production data. In the case of hydrocarbon emissions where gasoline evaporation was included but solvent evaporation was not, the totals are considerably lower than the actual values the results should, therefore, be viewed with these limitations in mind.

Fuel Combustion by Stationary Sources

Tables 4 through 6 present the consumption of fuel oil, coal and natural gas within the Study Area. As shown in these tables, fuel oil is the primary fuel used in the Area with coal and natural gas ranked second and third. During 1967, over 500 million gallons of fuel oil, 1.7 million tons of coal, and 25 billion cubic feet of natural gas were burned in the Study Area. In terms of the total energy supplied, fuel oil accounted for 51 percent, coal 30 percent, and natural gas 19 percent. The average chemical characteristics of the fuel are summarized in Table 17.

The power generating plants are the largest users of fuel in the Area. During 1967, they consumed 48 percent of the fuel oil and 94% of the coal. There are no natural gas operated power plants in the Area. The industry in the Area is moderate in size and only consumes 22 percent of the fuel oil and 10 percent of the natural gas.

Natural gas and fuel oil are both used quite heavily for heating of homes and offices. Over 12×10^{12} BTU's from natural gas and 20×10^{12} BTU's from fuel oil are used for this purpose. Coal is used very sparingly.

The emissions resulting from the burning of these fuels are summarized in Table 8. The use of fuels is the largest source for three out of five of the pollutants: sulfur oxides-97 percent, particulates-56 percent and nitrogen oxides-58 percent. The burning of fossil fuels is an insignificant source of carbon monoxide and hydrocarbons, emitting only 0.2 percent and 2.0 percent respectively.

Transportation Sources

In all, three types of transportation sources were considered. These include motor vehicles, aircraft and railroads. Vessels were not considered because of a lack of information. Tables 9 and 10 summarize vehicle miles and gasoline-diesel fuel consumption data which were used to calculate the emissions from motor vehicles. About 13 million vehicle miles of travel occur per day within the Study Area, of which about 2 percent is accounted for by diesel powered vehicles. This rate of travel consumes about 350 million gallons of gasoline and 10 million gallons of diesel fuel annually.

There are two major airports within the Study Area. The air traffic activity at each of these--T. F. Green State Airport and New Bedford Airport--is summarized in Tables 11-A and 11-B.

Approximately 210,000 itinerant operations and 190,000 local operations took place during 1967. A local operation is defined as a take-off or landing that originates and ends at the same airport. An itinerant operation is one that either originates or ends at the airport. Air carrier flights are primarily commercial, while general aviation includes all private and pleasure flights.

The third category in transportation, railroads, is by comparison minor. During 1967, an estimated five million gallons per year of fuel (diesel) were consumed in the Study Area.

The emissions from transportation sources are summarized in Table 12. Gasoline powered vehicles are by far the most significant source of air pollution. In 1967, they accounted for 98 percent of carbon monoxides, 93 percent of the hydrocarbons, 91 percent of the oxides of nitrogen, 69 percent of the particulate matter and 57 percent of the sulfur oxides (of the total transportation emissions.) Diesel powered vehicles were an important source in particulate emissions.

The emissions from aircraft, although minor overall, may be significant in that the emissions occur at two locations rather than throughout the Area as is the case in motor vehicles travel.

Refuse Disposal Sources

The estimated pattern of refuse disposal for the Study Area is summarized in Table 13. About 35 percent of the refuse is disposed of by open burning and 25 percent by sanitary landfills with the remainder being disposed of in incinerators or dumps. These are rough estimates and should be considered as such.

The emissions from burning of refuse is summarized in Table 14. On-site open burning is the primary source in the category.

Industrial Process Source

Industrial processes do not contribute substantially to the overall emissions in the Providence, New Bedford, Fall River Study Area.

The largest emitters in the Area are grey iron foundries and concrete batching facilities. Both together contribute about 1,000 tons of particulates per year. There is also a sulfuric acid plant that has an estimated emission rate of 50 tons sulfur oxides per year.

Point Source Emissions Vs. Total Emissions

Point source emissions which include both fuel burning and process infromation are presented in Table 15 . Point sources collectively account for the following percentages of the total pollutants:

Sulfur Oxides	72%
Particulates	2%
Carbon Monoxides	2%
Hydrocarbons	4%
Nitrogen Oxides	50%

TABLE 4 FUEL OIL CONSUMPTION BY SMSA
1967 (bbl./Year)

	Providence	New Bedford	Fall River	Total
Residential	2,550,000	440,000	370,000	3,360,000
Commercial	490,000	90,000	80,000	660,000
Industrial	2,000,000	400,000	300,000	2,700,000
Utilities	1,800,000	3,100,000	800,000	5,700,000
Total	6,840,000	4,030,000	1,550,000	12,420,000

TABLE 5 COAL CONSUMPTION BY SMSA, 1967
(TONS/YEAR)

	Providence	New Bedford	Fall River	Total
Residential	56,000	10,000	10,000	76,000
Commercial	Neg. *	Neg.	Neg.	Neg.
Industrial	14,000	NA**	NA	14,000
Utilities	160,000	Neg.	1,460,000	1,620,000
Total	230,000	10,000	1,470,000	1,710,000

*Neg. - Negigible
**NA - Not Available

TABLE 6 NATURAL GAS CONSUMPTION BY SMSA
1967 (MILLIONS CUBIC FEET/YEAR)

	Providence	New Bedford	Fall River	Total
Residential	12,500	3,200	3,000	18,700
Commercial	3,400	500	500	4,400
Industrial	1,500	700	600	2,800
Utilities	Neg. *	Neg.	Neg.	Neg.
Total	17,400	4,400	4,100	25,900

*Neg. - Negligible

TABLE 7 CHEMICAL ANALYSIS OF FUELS IN THE PROVIDENCE STUDY AREA, 1967

Fuel	Sulfur %	Ash %	Volatile %
Coal	0.7	5	
Residual Fuel Oil	2.25	--	--
Distillate Fuel Oil	0.24	--	--
Gas	0.0008	Neg.	--

TABLE 8 AIR POLLUTANT EMISSIONS FROM BURNING OF FUELS BY STATIONARY SOURCES IN PROVIDENCE STUDY AREA, 1967 (TONS/YEAR)

Source	Sulfur Oxides	Particulates	Carbon Monoxides	Hydrocarbons	Nitrogen Oxides
Industrial	19,200	2,050	120	100	5,540
Natural Gas	Neg.*	40	Neg.	Neg.	300
Fuel Oil	19,000	1,400	100	100	5,100
Coal	200	610	20	Neg.	140
Residential	24,900	1,790	2,040	590	1,250
Natural Gas	Neg.	180	Neg.	Neg.	1,100
Fuel Oil	23,900	560	140	210	850
Coal	1,000	950	1,900	380	300
Commercial	4,900	240	30	30	1,260
Natural Gas	Neg.	40	Neg.	Neg.	260
Fuel Gas	4,900	200	30	30	1,000
Coal	--	--	--	--	--
Utilities	67,100	10,400	400	560	29,000
Natural Gas	--	--	--	--	--
Fuel Oil	42,300	1,200	Neg.	380	12,500
Coal	24,800	9,200	400	180	16,500
Grand Total	116,100	14,480	2,590	1,280	37,050

*Neg. - Negligible

TABLE 9 NUMBER OF VEHICLE MILES TRAVELED IN PROVIDENCE STUDY AREA BY POLITICAL JURISDICTION, 1967
(Vehicle-Miles/Day)

	Gasoline Powered	Diesel Powered
Providence Pawtucket SMSA	10,063,000	129,000
Rhode Island Portion	8,473,000	110,000
Barrington	166,000	2,000
Bristol	166,000	3,000
Burrilliville	142,000	2,000
Central Falls	34,000	Neg.
Coventry	329,000	4,000
Cranston	779,000	11,000
Cumberland	410,000	5,000
East Greenwich	259,000	3,000
East Providence	561,000	7,000
Jamestown	40,000	Neg.
Johnston	321,000	4,000
Lincoln	280,000	3,000
Narragansett	134,000	1,000
North Kingstown	321,000	4,000
North Providence	231,000	3,000
North Smithfield	231,000	3,000
Pawtucket	512,000	7,000
Providence	1,450,000	20,000
Smithfield	197,000	2,000
Warren	118,000	1,000
Warwick	1,352,000	19,000
West Warwick	212,000	3,000
Woonsocket	228,000	3,000

TABLE 9 NUMBER OF VEHICLE MILES TRAVELED IN PROVIDENCE STUDY AREA BY POLITICAL JURISDICTION, 1967
(Vehicle-Miles/Day)

	Gasoline Powered	Diesel Powered
Massachusetts Portion	1,590,000	19,000
Attleboro	330,000	4,000
Bellingham	167,000	2,000
Blackstone	141,000	2,000
Franklin	183,000	2,000
Millville	44,000	Neg.
North Attleborough	183,000	2,000
Plainville	141,000	2,000
Rehoboth	141,000	2,000
Seekonk	212,000	3,000
Wrentham	47,000	Neg.
Fall River SMSA	1,181,000	15,000
Massachusetts Portion	1,026,000	13,000
Fall River	516,000	7,000
Somerset	160,000	2,000
Swansea	167,000	2,000
Westport	183,000	2,000
Rhode Island Portion	155,000	2,000
Tivertown	155,000	2,000
New Bedford SMSA	1,068,000	11,000
Acushnett	47,000	Neg.
Dartmouth	209,000	2,000

TABLE 9 NUMBER OF VEHICLE MILES TRAVELED IN PROVIDENCE STUDY AREA BY POLITICAL JURISDICTION, 1967
(Vehicle-Miles/Day)

	Gasoline Powered	Diesel Powered
Fairhaven	139,000	1,000
New Bedford	573,000	8,000
Marion	57,000	Neg.
Mattapoisett	43,000	Neg.
Extra Rhode Island Towns	642,000	7,000
Jamestown	40,000	Neg.
Middletown	180,000	2,000
Newport	158,000	2,000
Portsmouth	264,000	3,000
Grand Total	12,954,000	162,000

TABLE 10 GASOLINE AND DIESEL FUEL CONSUMPTION IN STUDY AREA BY SMSA, 1967
(10^6 gal./year)

	Gasoline		Diesel
	Consumption	Evaporation	Consumption
Providence	294	7	9
New Bedford	31	1	0.5
Fall Fiver	34	1	1
Total	359	9	10.5

TABLE 11-A AIR TRAFFIC ACTIVITY AT THEODORE FRANCIS
GREEN STATE AIRPORT, WARWICK, RHODE ISLAND
CALENDAR YEAR, 1967

	Itinerant Operations	Local Operation
Air Carrier	42,042	--
General Aviation	152,409	167,693
Military	1,476	610
Total	170,326	168,303

TABLE 11-B AIR TRAFFIC ACTIVITY AT NEW BEDFORD
AIRPORT , NEW BEDFORD MASSACHUSETTS
CALENDAR YEAR, 1967

	Itinerant Operations	Local Operations
Air Carrier	3,818	---
General Aviation	35,389	15,966
Military	1,958	5,238
Total	41,165	21,204

TABLE 12 AIR POLLUTANT EMISSIONS FROM TRANSPORTATION SOURCES IN PROVIDENCE STUDY AREA, 1967 (Tons/Year)

	Sulfur Oxides	Particulates	Carbon Monoxides	Hydrocarbons	Nitrogen Oxides
Road Vehicles	1,680	2,620	407,900	31,300	21,600
Gasoline	1,420	1,900	407,500	30,400	20,100
Diesel	260	720	400	900	1,500
Aircraft	Neg.	100	7,640	1,560	430
Jet	Neg.	10	7,110	510	250
Piston	Neg.	90	530	1,050	180
Railroad	830	50	Neg.	Neg.	170
Totals	2,510	2,770	415,540	32,860	22,200

TABLE 13 REFUSE BALANCE FOR PROVIDENCE STUDY AREA, 1967 (Tons/Year)

Jurisdiction	Total Refuse	Incineration		Landfills	Dumps	Open On-site Burning	Transferred
		Municipal	On-site				
Providence Pawtucket SMSA	715,150	132,000	40,000	174,800	103,900	261,400	
Rhode Island Portion	623,700	132,000	40,000	138,800	82,000	227,900	
Barrington	13,500			7,000		6,500	
Bristol	13,100				4,000	9,100	
Burrilliville	8,000				4,000	4,000	
Central Falls	15,500					8,500	-7,000
Coventry	14,600			8,000		6,600	
Cranston	59,800			30,000		29,800	
Cumberland	19,800			30,000		11,800	+22,000
East Greenwich	6,800			3,300		3,500	
East Providence	35,200			20,000	1,000	14,200	
Jamestown	2,100				500	1,700	
Johnston	16,200			10,000		6,200	
Lincoln	12,100					4,100	-8,000
Narragansett	4,200					4,200	
North Kingstown	19,100				11,000	8,100	

TABLE 13 REFUSE BALANCE FOR PROVIDENCE STUDY AREA, 1967 (Tons/Year)

Jurisdiction	Total Refuse	Incineration		Landfills	Dumps	Open On-site Burning	Transferred
		Municipal	On-site				
North Providence	17,600				12,000	5,000	
North Smithfield	7,200					4,200	-3,000
Pawtucket	64,200	45,000	10,000	7,000		9,200	+7,000
Providence	155,000	62,000	20,000	15,000	5,000	31,000	-22,000
Smithfield	9,900				3,500	6,400	
Warren	8,100			2,500		5,600	
Warwick	64,500		10,000		30,000	24,000	
West Warwick	18,200				11,000	7,200	
Woonsocket	39,000	25,000		6,000		19,000	+11,000
Massachusetts Portion	91,400			36,000	21,900	33,500	
Attleboro	24,900			17,500		7,400	
Bellingham	10,000				6,000	4,000	
Blackstone	5,300				3,200	2,100	
Franklin	13,400				8,100	5,300	
Millville	1,400				800	600	
North Attleborough	13,100			8,200		4,900	
Plainville	3,700			2,500		1,200	

TABLE 13 REFUSE BALANCE FOR PROVIDENCE STUDY AREA, (Tons/Year)

Jurisdiction	Total Refuse	Incineration Municipal	Incineration On-site	Landfills	Dumps	Open On-site Burning	Transferred
Rehoboth	4,600			2,700		1,900	
Seekonk	8,600			5,100		3,500	
Wrentham	6,400				3,800	2,600	
Fall River SMSA	124,500	15,000	2,000	65,200	4,300	38,000	
Massachusetts Portion	115,300	15,000	2,000	59,200	4,300	34,800	
Fall River	84,500	15,000	2,000	45,000		22,500	
Somerset	13,400			8,100		5,300	
Swansea	10,200			6,100		4,100	
Westport	7,200				4,300	2,900	
Rhode Island Portion	9,200			6,000		3,200	
Tivertown	9,200			6,000		3,200	
New Bedford SMSA	121,200	20,000		13,100	55,800	32,300	
Acushnet	5,800			3,500		2,300	
Dartmouth	14,500				8,700	5,800	

TABLE 13 REFUSE BALANCE FOR PROVIDENCE STUDY AREA, (Tons/Year)

Jurisdiction	Total Refuse	Incineration Municipal	Incineration On-site	Landfills	Dumps	Open On-site Burning	Transferred
Fairhaven	13,400			8,100		5,300	
New Bedford	81,500	20,000			45,000	16,500	
Marion	2,500			1,500		1,000	
Mattapoisett	3,500				2,100	1,400	
Other Massachusetts Towns	56,700	21,000		19,000	5,500	12,200	
Jamestown	2,200				500	1,700	
Middletown	16,200			13,000		3,200	
Newport	29,500	21,000			5,000	4,500	
Portsmouth	8,800			6,000		2,800	
Totals	1,017,500	188,000	42,000	272,100	169,500	345,900	

TABLE 14 AIR POLLUTANT EMISSIONS FROM SOLID WASTE DISPOSAL IN PROVIDENCE STUDY AREA (Tons/Year)

	SO_x	PART.	CO	HC	NO_x
Total Incineration	230	1,800	1,000	50	250
Municipal	190	1,600	100	30	190
On-site	40	200	900	20	60
Total Open Burning	Neg.*	3,430	18,200	1,100	2,360
Dumps	Neg.	680	3,600	220	470
On-site	Neg.	2,750	14,600	880	1,890
Total	230	5,230	19,200	1,150	2,610

Neg. - Negligible

METHODOLOGY

The following discussion is a summary of procedures employed in Providence, New Bedford, Fall River emission inventory.

Fuel Combustion by Stationary Sources

The state air pollution agencies were contacted as to the use of fossil fuels in the major industrial and commercial establishments. Approximately 100 major industries and commercial establishments were located and their fuel consumption totaled. This amounted to approximately 350 million gallons of fuel oil, one billion cubic feet of natural gas and 1.6 thousand tons of coal. The large industrial and commercial facilities consumed most of the fuel oil and natural gas and the power plants used coal and fuel oil. On the basis of this information, 70 percent of the fuel oil and 96 percent of the coal burned in the area was accounted for by point sources. The balance of the fuel burned in the Study Area was distributed to three area source categories of fuel consumption: (1) residential, (2) commercial-institutional and (3) industry.

The amount of fuel burned for home heating was calculated using the procedure described in the "Rapid Survey Technique". The method includes such variables as total annual and winter degree days, average number of rooms per dwelling unit, and the number of dwelling units using each fuel. It was assumed that all fuel oil burned for home heating was distillate.

Commercial-Institutional fuel consumption figures were not available except in the case of natural gas where the gas companies had supplied their figures. Natural gas for commercial establishments was found to be about from one fourth to one sixth of the amount sold to residential users. Fuel oil was determined by point sources and other reports already completed. It was assumed the coal consumption would be negligible for this category.

After the approximate fuel consumption was determined all point sources, residential and commercial figures were subtracted from the total. The remainder was considered industrial and distributed to those areas in the Study Area considered industrialized.

Transportation Sources

Transportation information was obtained from two major sources: (1) the State Highway Department of Massachusetts. and (2) the State Highway Department of Rhode Island.

The State of Rhode Island had reliable information on the number of vehicle miles driven in all cities and towns in Rhode Island. The State of Massachusetts had a transportation study of Southeastern Massachusetts that gave vehicle miles for most towns in the Area. The remaining Massachusetts towns were estimated by population.

Refuse Disposal

Solid waste information was supplied by both Health Departments which had surveyed most of the dumps, landfills and incinerators in the Area. With this information and approximate amount of refuse being generated in the area a refuse balance was generated. That part of the solid waste being disposed of by open burning was distributed through the Study Area by population.

Industrial Process Emissions

The information used to estimate the process emissions from point sources was gathered by the acknowledged air pollution agencies. This data was most often in the form of production figures because actual process emissions, for the most part, were not available.

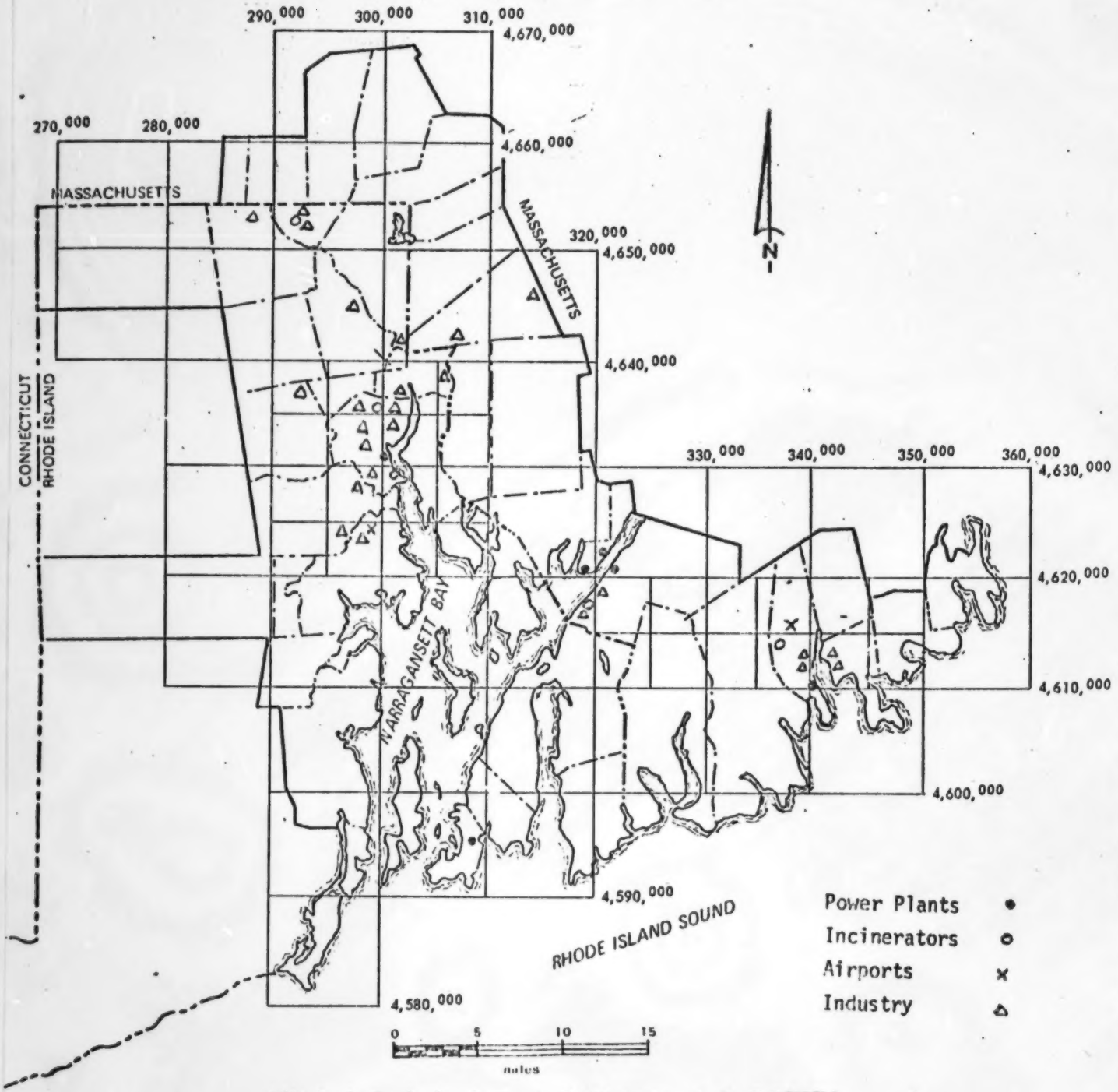

Figure 3. Point source locations in the Providence-Pawtucket, New Bedford, and Fall River Study Area

Figure 1. Providence-Pawtucket, Fall River and New Bedford Study Area.

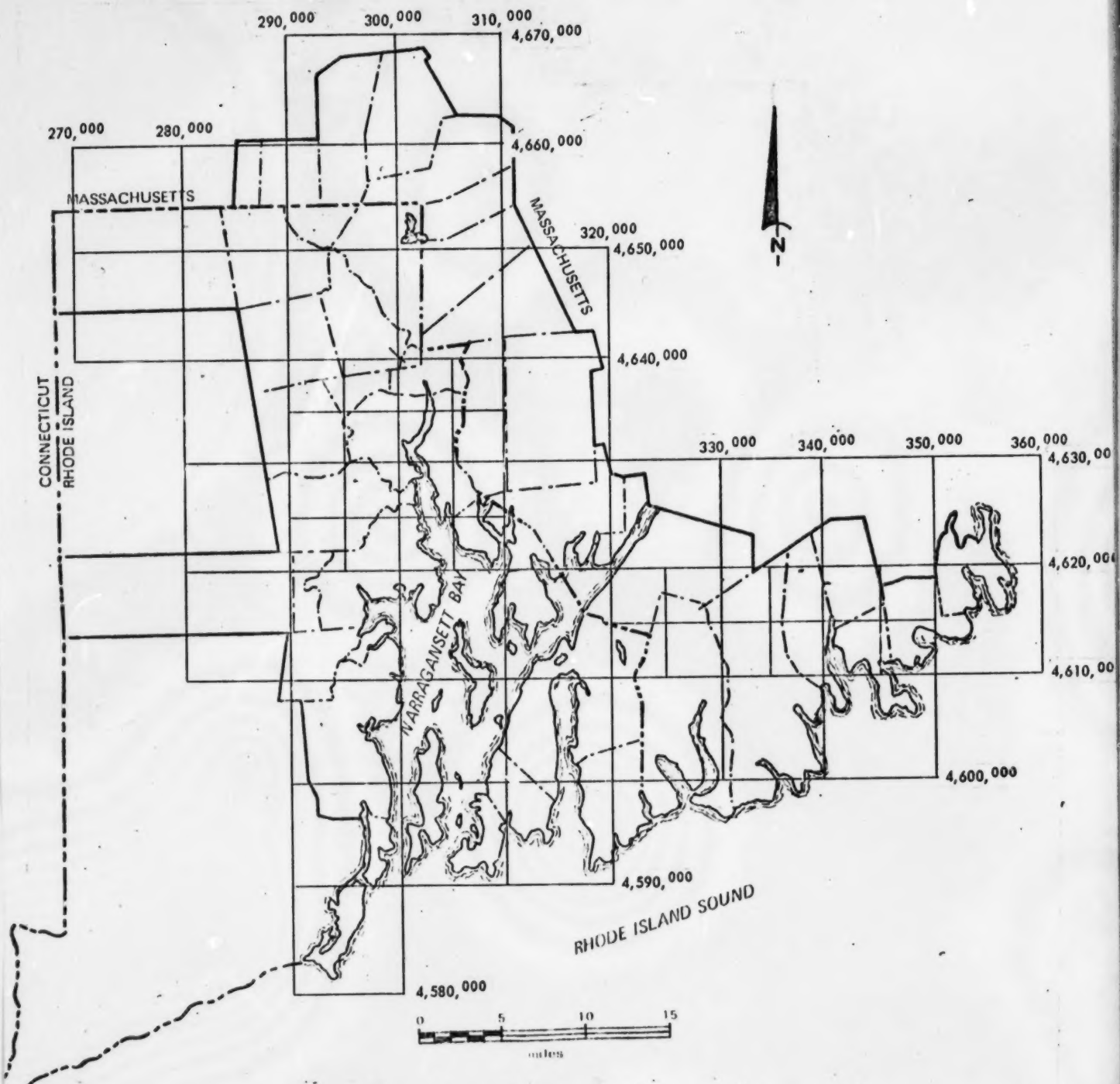

Figure 2. Grid system of Providence study area.

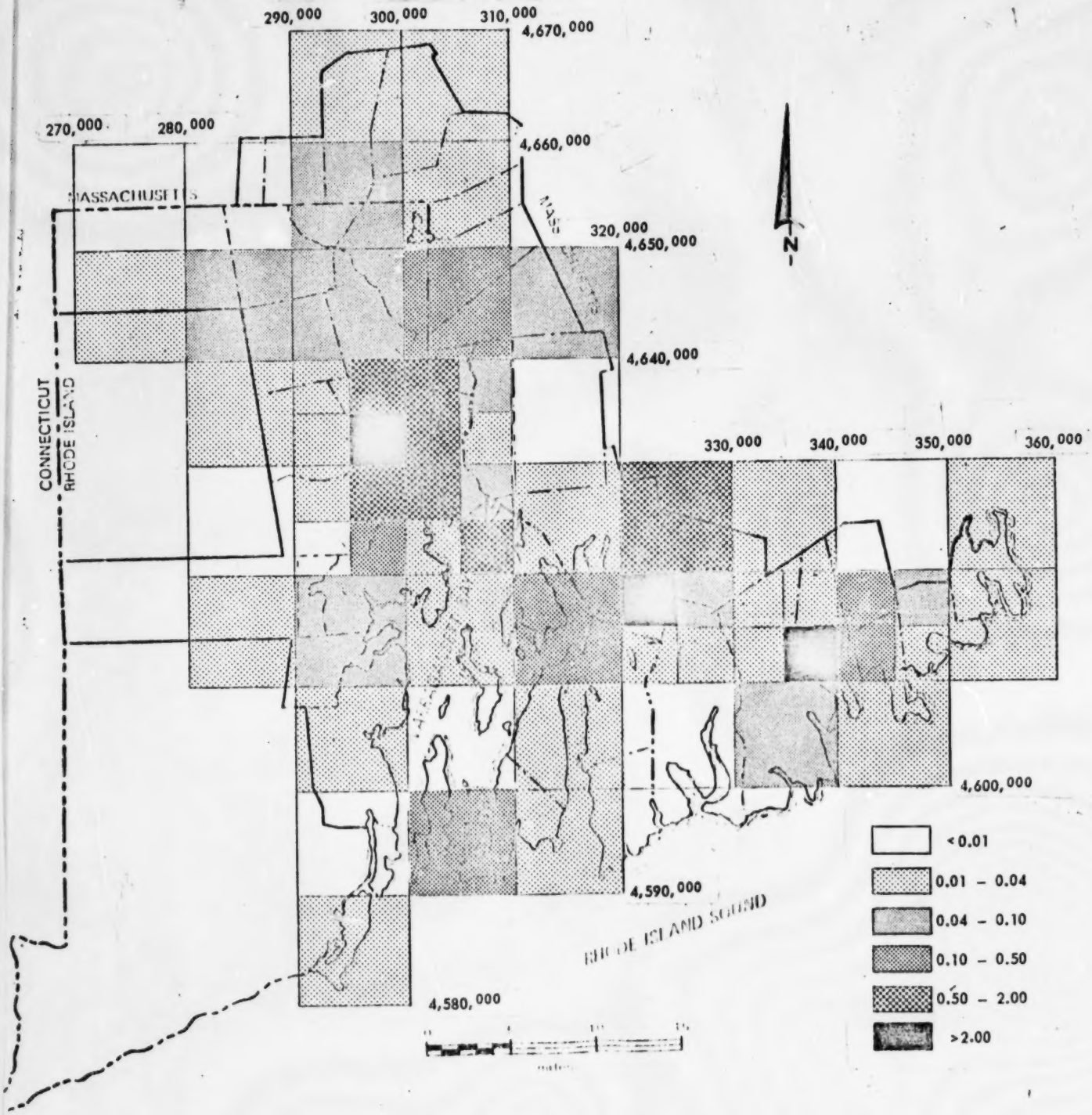

Figure 4. Sulfur oxide emission density map for Providence study area.

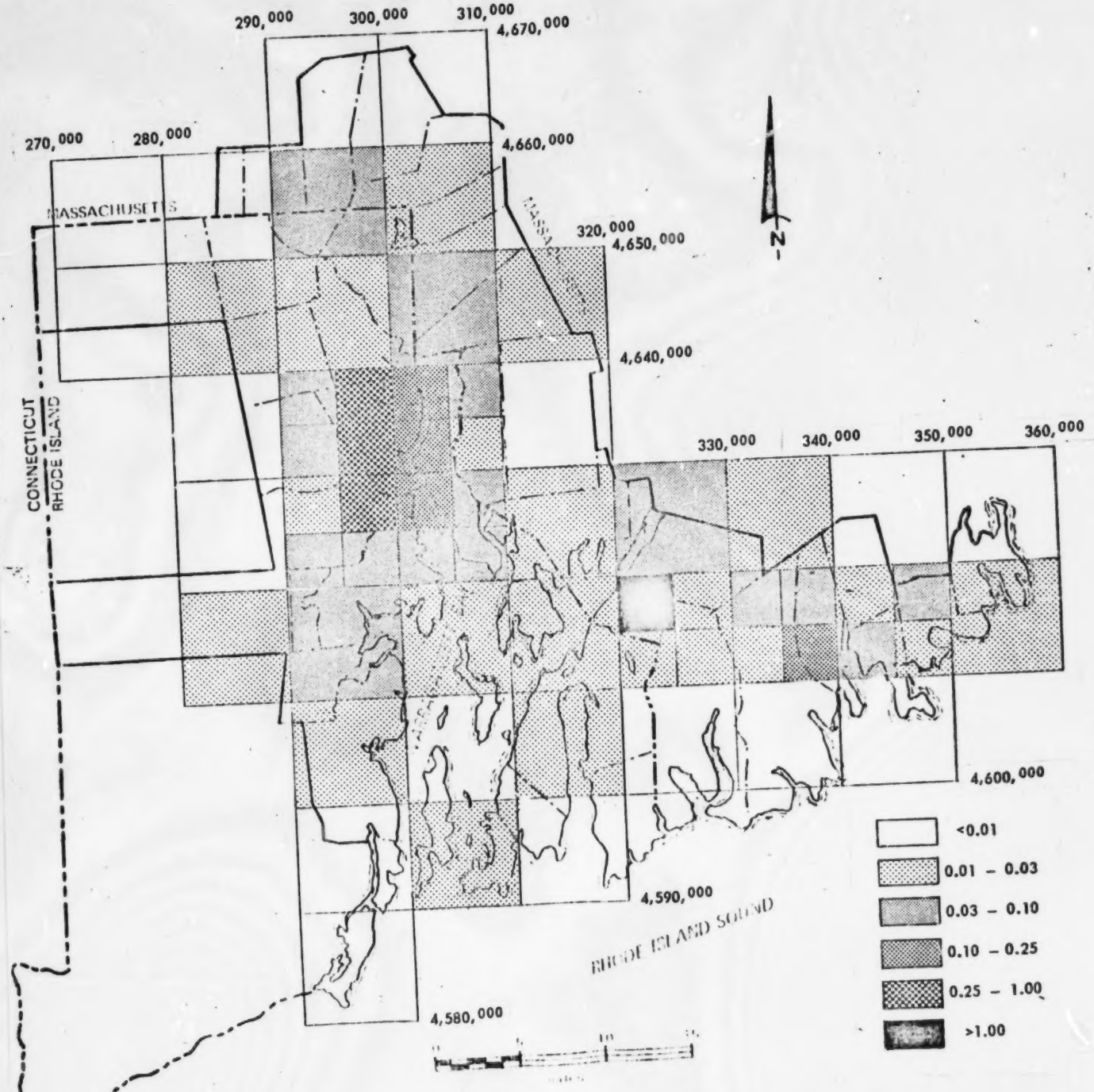

Figure 5. Particulate emission density map for Providence study area.

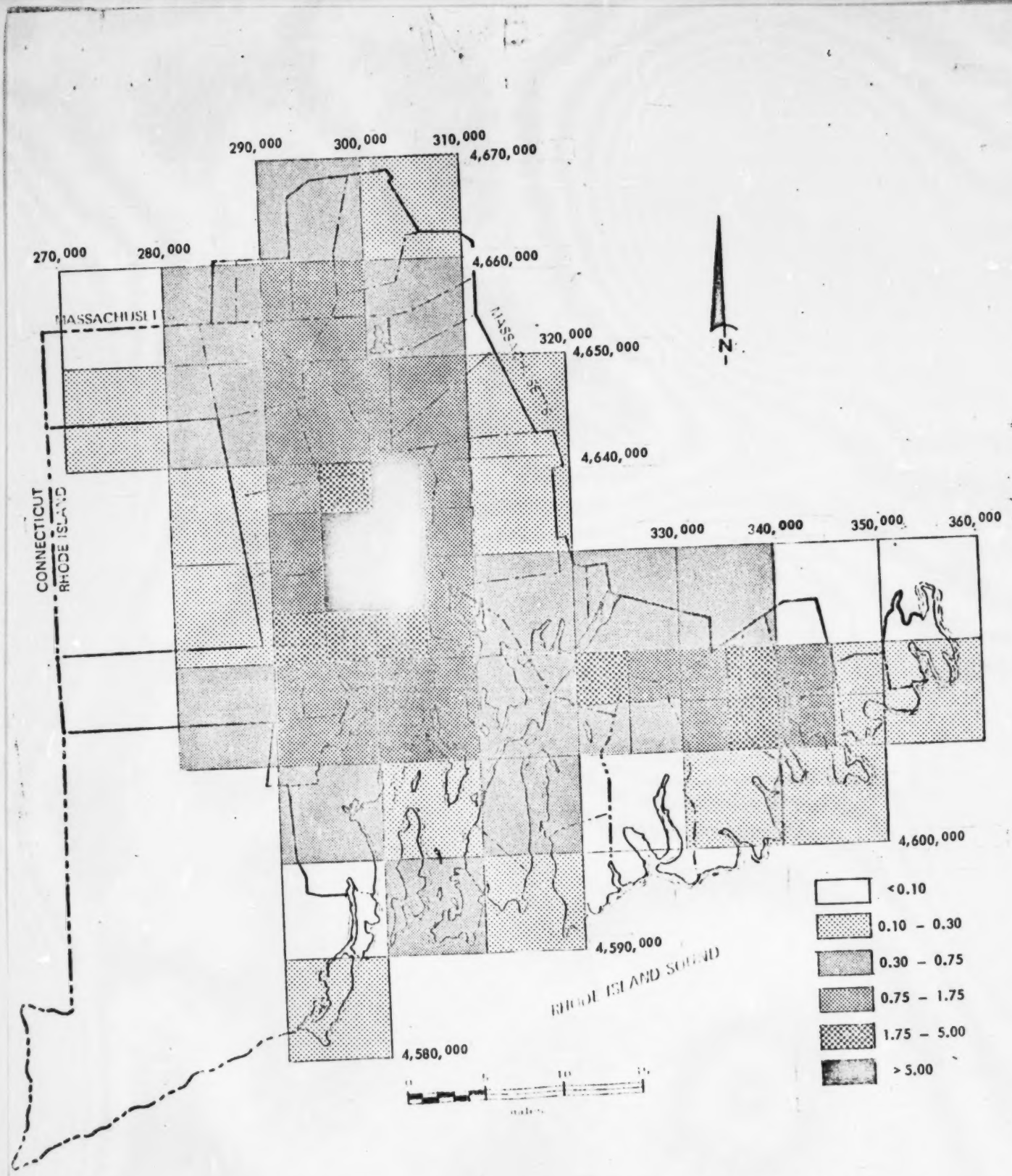

Figure 6. Carbon monoxide emission density map for Providence study area.

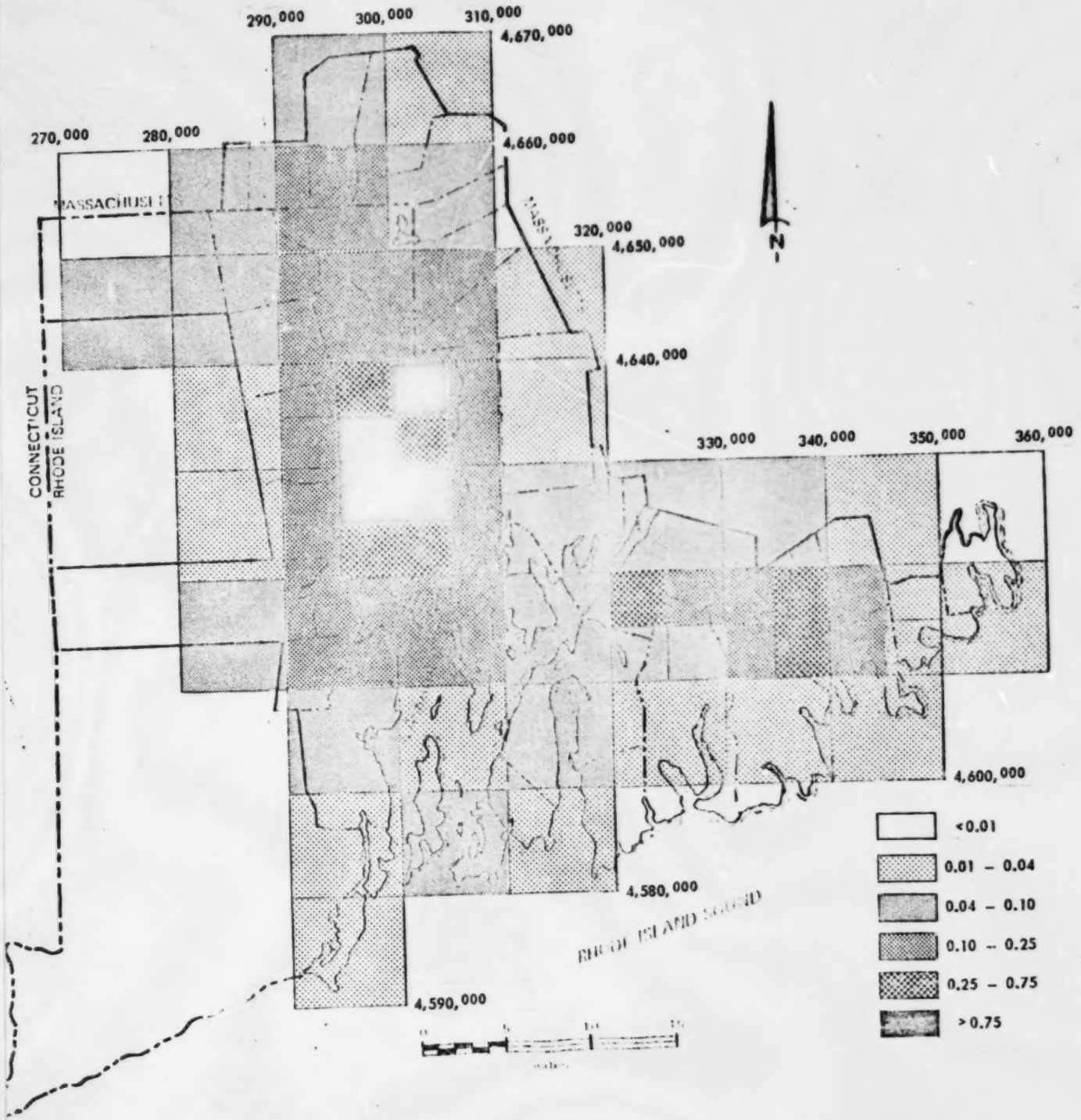

Figure 7. Hydrocarbon emission density map for Providence study area.

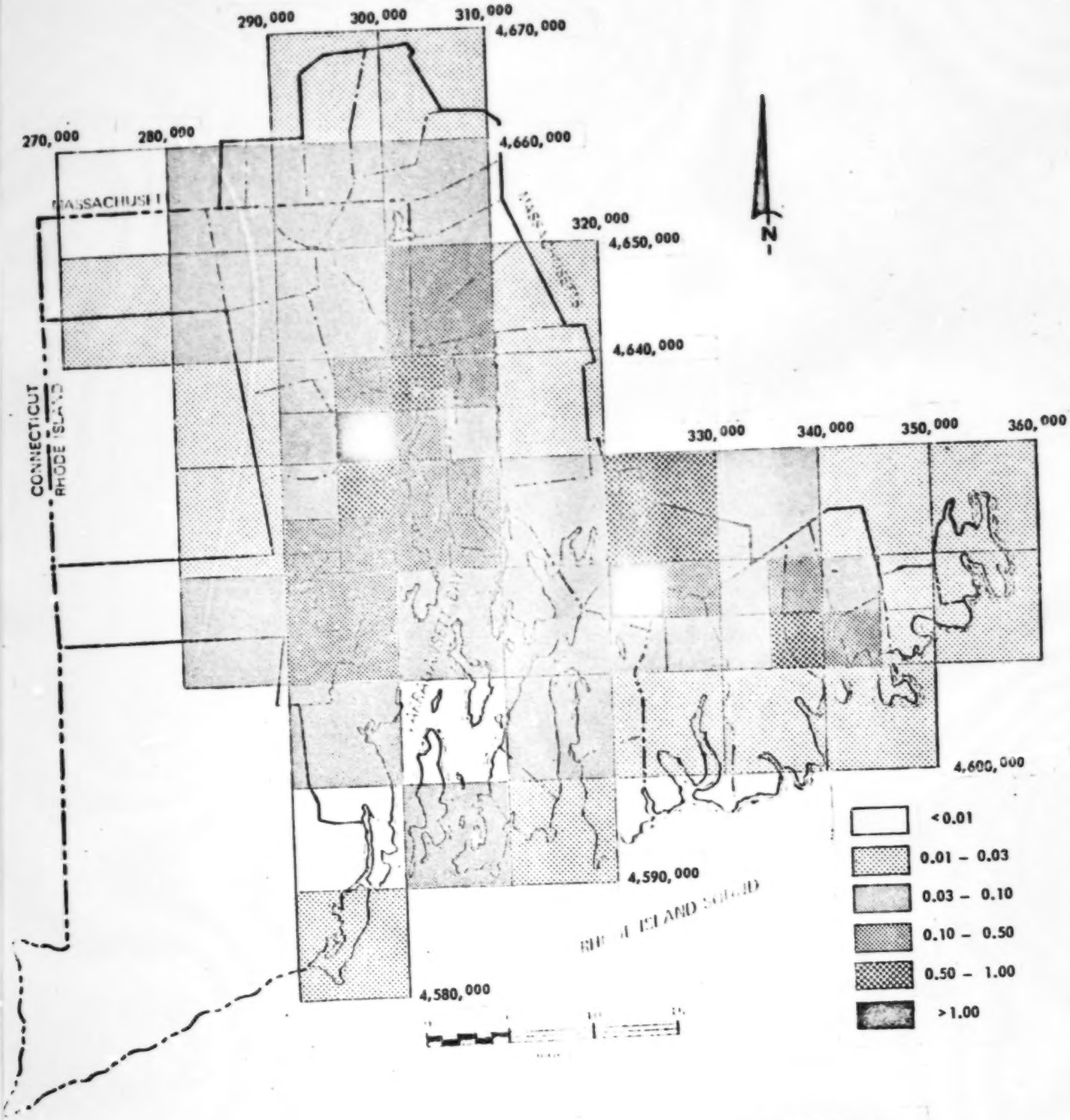

Figure 8. Nitrogen oxide emission density map for Providence study area.

TABLE SUMMARY OF AREA SOURCE EMISSIONS FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY AREA, 1967 (TONS/DAY)

Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	Area (sq mi)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	CO AVG.
1	2750	46550	38.60	0.00	0.00	0.00	0.00	0.00	0.00	.57	.49	.53
2	2850	46550	38.60	.10	.23	.16	.06	.18	.17	15.45	13.35	14.33
3	2950	46550	38.60	.19	2.67	1.50	.78	1.36	1.27	41.12	36.11	38.51
4.	3050	46550	38.60	.12	.87	.48	.30	.47	.38	28.19	24.50	26.22
5	2750	46450	38.60	.05	.44	.26	.15	.22	.19	11.92	10.35	11.07
6	2850	46450	38.60	.06	.40	.23	.16	.23	.19	14.03	12.18	13.02
7	2950	46450	38.60	.21	1.21	.70	.51	.64	.57	37.04	32.08	34.40
8	3050	46450	38.60	.40	2.98	1.80	.68	1.23	.94	49.44	44.11	47.03
9	3150	46450	38.60	.16	.45	.32	.10	.12	.10	7.03	6.09	6.53
10	2850	46350	38.60	.21	1.29	.77	.11	.19	.15	7.80	6.75	7.24
11	2925	46375	9.65	.06	.59	.30	.40	.53	.46	15.00	13.03	13.97
12	2975	46375	9.65	6.64	8.62	7.60	1.03	1.55	1.27	38.86	34.06	36.35
13	3025	46375	9.65	7.01	11.75	9.70	1.35	3.06	2.10	70.95	63.38	66.74
14	3075	46375	9.65	.07	.68	.38	.25	.35	.29	16.50	14.30	15.32
15	2925	46325	9.65	.04	.40	.21	.22	.35	.30	11.88	10.37	11.07
16	2975	46325	9.65	7.35	13.98	10.86	1.52	3.07	3.27	92.95	80.88	86.96
17	3025	46325	9.65	6.64	8.72	7.75	.96	1.55	1.25	46.06	40.42	43.01

TABLE SUMMARY OF AREA SOURCE EMISSIONS FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY AREA, 1967 (TONS/DAY)

Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	Area (sq mi)	SO SUM.	SO WIN.	SO AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	CO AVG.
18	3075	46325	9.65	.04	.38	.21	.12	.22	.17	11.11	9.70	10.36
19	3150	46350	38.60	.06	.14	.10	.06	.06	.06	4.98	4.30	4.62
20	2850	46250	38.60	.05	.34	.19	.14	.18	.16	9.79	8.47	9.09
21	2925	46275	9.65	.04	.41	.22	.14	.21	.17	11.75	10.21	10.93
22	2975	46275	9.65	6.79	10.38	8.58	1.46	2.96	1.98	83.00	70.90	75.55
23	3025	46275	9.65	6.70	9.07	7.86	1.19	1.76	1.47	76.13	65.31	70.86
24	3075	46275	9.65	.09	.75	.40	.25	.37	.31	17.94	15.64	16.70
25	2925	46225	9.65	.07	.66	.36	.23	.33	.28	18.83	16.34	17.49
26	2975	46225	9.65	.15	1.42	.77	.49	.77	.62	33.18	28.95	30.92
27	3025	46225	9.65	.11	.44	.27	.26	.35	.30	24.78	21.53	23.04
28	3075	46225	9.65	.09	.69	.38	.24	.36	.30	17.84	15.50	16.59
29	3150	46250	38.60	.15	1.45	.82	.46	.71	.57	24.73	21.59	23.05
30	3250	46250	38.60	1.27	3.25	2.25	.60	.93	.75	12.55	10.95	13.64
31	3350	46250	38.60	.08	1.84	.95	.46	.73	.60	13.33	11.91	12.64
32	3450	46250	38.60	.01	.33	.17	.07	.14	.10	2.56	2.28	2.40
33	2850	46150	38.60	.11	.89	.50	.26	.36	.31	19.92	17.32	18.32
34	2950	46150	38.60	.52	2.70	1.63	.79	1.30	1.04	69.27	60.29	64.46
35	3050	46150	38.60	.15	1.02	.58	.37	.58	.47	34.46	29.95	32.05
36	3150	46150	38.60	1.20	2.16	1.76	.36	.61	.48	20.94	18.37	19.56
37	3225	46175	9.65	1.33	2.95	2.14	.33	.88	.58	21.90	19.43	20.64

TABLE SUMMARY OF AREA SOURCE EMISSIONS FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY AREA, 1967 (TONS/DAY)

Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	Area (sq mi)	SO SUM.	SO WIN.	SO AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	CO AVG.
38	3275	46175	9.65	.05	.67	.35	.14	.27	.21	8.16	7.19	7.53
39	3325	46175	9.65	.05	.50	.27	.33	.40	.37	10.37	9.13	9.71
40	3375	46175	9.65	.10	2.03	1.06	.40	.83	.61	19.29	16.13	17.12
41	3425	46175	9.65	.03	.48	.25	.10	.21	.16	8.03	6.95	7.50
42	3475	46175	9.65	0.00	.74	.37	.17	.29	.33	1.65	1.59	1.61
43	3550	46150	38.60	.03	1.75	.88	.28	.66	.46	4.76	4.53	4.63
44	3550	46250	38.60	0.00	.46	.23	.07	.15	.11	1.56	1.40	1.47
45	3225	46125	9.65	.02	.14	.08	.05	.05	.05	5.57	4.80	5.16
46	3275	46125	9.65	.02	.12	.07	.05	.05	.06	5.77	4.98	5.35
47	3325	46125	9.65	.05	.36	.20	.14	.17	.16	9.35	8.10	8.68
48	3375	46125	9.64	1.43	2.89	2.35	.49	1.26	.86	31.03	27.56	29.11
49	3425	46125	9.65	1.59	2.61	2.11	.28	.61	.34	13.34	11.76	12.14
50	3475	46125	9.65	.01	.36	.18	.07	.13	.10	2.44	2.15	2.28
51	2950	46050	38.60	.07	.54	.31	.21	.27	.24	14.43	12.50	13.39
52	3050	46050	38.60	.02	.28	.15	.09	.14	.12	6.86	5.95	6.37
53	3150	46050	38.60	.12	.77	.46	.27	.49	.38	28.60	24.74	26.55
54	3250	46050	38.60	.01	.19	.10	.05	.07	.06	2.34	2.04	2.18

TABLE 15 SUMMARY OF EMISSIONS FROM POINT SOURCES IN PROVIDENCE, NEW BEDFORD, AND FALL

Source Category	Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	CO AVG
Incinerator	12	2998	46378	0.12	0.12	0.12	1.05	1.05	1.05	0.06	0.06	0.0
Incinerator	23	3015	46297	0.17	0.17	0.17	1.44	1.44	1.44	0.08	0.08	0.0
Incinerator	3	2932	46528	0.07	0.07	0.07	0.58	0.58	0.58	0.03	0.03	0.0
Incinerator	36	3173	46170	0.04	0.04	0.04	0.35	0.35	0.35	0.02	0.02	0.0
Incinerator	48	3370	46143	0.05	0.05	0.05	0.47	0.47	0.47	0.02	0.02	0.0
Airport	40	3370	46155	0.00	0.00	0.00	0.02	0.02	0.02	4.37	4.37	4.3
Airport	26	2975	46220	0.00	0.00	0.00	0.25	0.25	0.25	16.55	16.55	16.5
Industry	3	2925	46539	0.09	0.63	0.44	0.01	0.04	0.03	0.00	0.00	0.0
Industry	3	2926	46534	0.17	0.57	0.43	0.01	0.04	0.03	0.00	0.00	0.0
Industry	2	2880	46600	0.00	2.05	1.30	0.00	0.13	0.09	0.00	0.01	0.0
Industry	11	2936	46378	0.00	0.68	0.32	0.00	0.05	0.02	0.00	0.00	0.0
Industry	7	2986	46458	1.86	2.59	2.33	0.13	0.18	0.16	0.01	0.01	0.0
Industry	8	3004	46408	2.58	2.80	2.72	0.17	0.18	0.18	0.01	0.02	0.0
Industry	8	3070	46408	4.70	5.52	5.22	0.31	0.36	0.34	0.03	0.03	0.0
Industry	9	3115	46462	1.24	1.73	1.55	0.08	0.11	0.10	0.01	0.01	0.0
Institution	12	2978	46352	0.00	0.81	0.51	0.00	0.05	0.03	0.00	0.00	0.0
Institution	12	2954	46359	0.05	0.70	0.46	0.00	0.05	0.03	0.00	0.00	0.0
Industry	13	3021	46376	1.12	1.12	1.10	0.03	0.03	0.03	0.00	0.00	0.0
Institution	13	3005	46357	0.10	0.60	0.34	0.01	0.04	0.02	0.00	0.00	0.0
Industry	13	3003	46369	0.16	0.54	0.40	0.01	0.04	0.03	0.00	0.00	0.0
Industry	14	3051	46394	0.27	0.56	0.45	0.02	0.04	0.03	0.00	0.00	0.0

T SOURCES IN PROVIDENCE, NEW BEDFORD, AND FALL RIVER STUDY AREA, 1967 (TONS/DAY)

PART.			CO			HC			NO_x		
SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.
1.05	1.05	1.05	0.06	0.06	0.06	0.02	0.02	0.02	0.12	0.12	0.12
1.44	1.44	1.44	0.08	0.08	0.08	0.03	0.03	0.03	0.17	0.17	0.17
0.58	0.58	0.58	0.03	0.03	0.03	0.01	0.01	0.01	0.07	0.07	0.07
0.35	0.35	0.35	0.02	0.02	0.02	0.01	0.01	0.01	0.04	0.04	0.04
0.47	0.47	0.47	0.02	0.02	0.02	0.01	0.01	0.01	0.05	0.05	0.05
0.02	0.02	0.02	4.37	4.37	4.37	0.81	0.81	0.81	0.21	0.21	0.21
0.25	0.25	0.25	16.55	16.55	16.55	3.44	3.44	3.44	.97	.97	.97
0.01	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13	0.09
0.01	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.12	0.09
0.00	0.13	0.09	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.52	0.27
0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.07
0.13	0.18	0.16	0.01	0.01	0.01	0.01	0.01	0.01	0.43	0.60	0.54
0.17	0.18	0.18	0.01	0.02	0.02	0.01	0.02	0.02	0.53	0.58	0.56
0.31	0.36	0.34	0.03	0.03	0.03	0.03	0.03	0.03	0.97	1.14	1.08
0.08	0.11	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.26	0.36	0.32
0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.11
0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	0.10
0.03	0.03	0.03	0.00	0.00	0.00	0.01	0.01	0.01	0.33	0.33	0.33
0.01	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.10
0.01	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.11	0.08
0.02	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.11	0.09

TABLE 15 SUMMARY OF EMISSIONS FROM POINT SOURCES IN PROVIDENCE, NEW BEDFORD, AND FA

Source Category	Grid	Hor. Coor. (100m)	Vert Coor. (100m)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	A
Industry	16	2975	46306	0.78	1.08	0.97	0.06	0.09	0.08	0.00	0.01	0
Industry	16	2997	46317	0.36	0.51	0.45	0.02	0.03	0.03	0.00	0.00	0
Institution	16	2998	46314	0.67	2.11	1.35	0.04	0.14	0.09	0.00	0.01	0
Power Plant	16	2998	46323	48.96	48.96	48.96	2.10	2.10	2.10	0.12	0.12	0
Institution	17	3002	46329	0.74	0.74	0.74	0.03	0.03	0.03	0.00	0.00	0
Industry	17	3213	46167	0.48	1.40	1.06	0.03	0.09	0.07	0.00	0.01	0
Industry	22	2983	46275	0.86	0.93	0.90	1.80	1.80	1.80	0.00	0.01	0
Industry	22	2988	46276	0.41	0.58	0.52	0.03	0.04	0.04	0.00	0.00	0
Industry	22	2992	46298	0.32	0.65	0.53	0.02	0.04	0.03	0.00	0.00	0
Industry	26	2980	46209	0.21	0.71	0.53	0.01	0.05	0.03	0.00	0.00	0
Industry	26	2966	46221	0.31	0.64	0.52	0.02	0.04	0.03	0.00	0.00	0
Industry	26	2950	46222	1.46	1.71	1.62	0.10	0.11	0.11	0.01	0.01	0
Industry	28	3050	46290	7.55	7.55	7.55	0.50	0.50	0.50	0.04	0.04	0
Power Plant	30	3205	46202	0.84	0.84	0.84	0.02	0.02	0.02	0.00	0.00	0
Power Plant	30	3215	46230	62.18	62.18	62.18	1.78	1.78	1.78	0.01	0.01	0
Industry	36	3195	46185	0.94	1.10	1.04	0.06	0.07	0.07	0.01	0.01	0
Industry	36	3112	46155	0.71	1.63	1.29	0.05	0.11	0.08	0.00	0.01	0
Industry	48	3397	46085	0.54	0.76	0.68	0.04	0.05	0.04	0.00	0.00	0
Industry	48	3395	46120	0.08	0.59	0.41	0.01	0.04	0.03	0.00	0.00	0
Power Plant	48	3390	46100	16.07	16.07	16.07	0.46	0.46	0.46	0.00	0.00	0

OINT SOURCES IN PROVIDENCE, NEW BEDFORD, AND FALL RIVER STUDY AREA, 1967 (TONS/DAY)

G.	SUM.	PART. WIN.	AVG.	SUM.	CO WIN.	AVG.	SUM.	HC WIN.	AVG.	SUM.	NO_x WIN.	AVG.
.97	0.06	0.09	0.08	0.00	0.01	0.01	0.00	0.01	0.01	0.28	0.40	0.35
.45	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.11	0.09
.35	0.04	0.14	0.09	0.00	0.01	0.01	0.00	0.01	0.01	0.14	0.43	0.28
.96	2.10	2.10	2.10	0.12	0.12	0.12	0.38	0.38	0.38	15.25	15.25	15.25
.74	0.03	0.03	0.03	0.00	0.00	0.00	0.01	0.01	0.01	0.32	0.32	0.32
.06	0.03	0.09	0.07	0.00	0.01	0.01	0.00	0.01	0.01	0.10	0.29	0.22
.90	1.80	1.80	1.80	0.00	0.01	0.01	0.00	0.01	0.01	0.18	0.20	0.19
.52	0.03	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.19	0.17
.53	0.02	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.11
.53	0.01	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.15	0.11
.52	0.02	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.11
.62	0.10	0.11	0.11	0.01	0.01	0.01	0.01	0.01	0.01	0.30	0.35	0.33
.55	0.50	0.50	0.50	0.04	0.04	0.04	0.04	0.04	0.04	1.57	1.57	1.57
.84	0.02	0.02	0.02	0.00	0.00	0.00	0.01	0.01	0.01	0.25	0.25	0.25
.18	1.78	1.78	1.78	0.01	0.01	0.01	0 57	0.57	0.57	18.49	18.49	18.49
.04	0.06	0.07	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.20	0.23	0.22
.29	0.05	0.11	0.08	0.00	0.01	0.01	0.00	0.01	0.01	0.15	0.33	0.27
.68	0.04	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.16	0.14
0.41	0.01	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.08
.07	0.46	0.46	0.46	0.00	0.00	0.00	0.15	0.15	0.15	4.78	4.78	4.78

TABLE 15 SUMMARY OF EMISSIONS FROM POINT SOURCES IN PROVIDENCE, NEW BEDFORD, AND FALL

Source Category	Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	CO AVG
Industry	49	3400	45146	0.66	0.84	0.78	0.04	0.06	0.05	0.00	0.00	0.0
Industry	49	3400	45150	0.31	0.80	0.63	0.02	0.05	0.04	0.00	0.00	0.0
Power Plant	37	3173	46200	53.20	53.20	53.20	24.00	24.00	24.00	1.00	1.00	1.0
Power Plant	58	3080	45960	2.55	2.55	2.55	0.07	0.07	0.07	0.00	0.00	0.0

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INT SOURCES IN PROVIDENCE, NEW BEDFORD, AND FALL RIVER STUDY AREA, 1967 (TONS/DAY)

	PART.			CO			HC			NO_x	
SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.
0.04	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.17	0.16
0.02	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.13
24.00	24.00	24.00	1.00	1.00	1.00	0.40	0.40	0.40	40.00	40.00	40.00
0.07	0.07	0.07	0.00	0.00	0.00	0.02	0.02	0.02	0.75	0.75	0.75

TABLE 16 SUMMARY OF TOTAL SOURCE EMISSIONS BY GRID FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY A

1967 (TONS/DAY)

Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	Area (sq mi)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	
1	2750	46550	38.60	0.00	0.00	0.00	0.00	0.00	0.00	.57	.49	
2	2850	46550	38.60	.10	2.28	1.46	.06	.31	.26	15.45	13.36	1
3	2950	46550	38.60	.52	3.94	2.44	1.38	2.02	1.91	41.15	36.14	3
4	3050	46550	38.60	.12	.87	.48	.30	.47	.38	28.19	24.50	2
5	2750	46450	38.60	.05	.44	.26	.15	.22	.19	11.92	10.35	1
6	2850	46450	38.60	.06	.40	.23	.16	.23	.19	14.03	12.18	1
7	2950	46450	38.60	2.07	3.80	3.03	.64	.82	.73	37.05	32.09	3
8	3050	46450	38.60	7.58	11.30	9.74	1.16	1.77	1.46	49.48	44.16	4
9	3150	46450	38.60	1.40	2.18	1.87	.18	.23	.20	7.04	6.10	
10	2850	46350	38.60	.21	1.29	.77	.11	.19	.15	7.80	6.75	
11	2925	46375	9.65	.06	1.27	,64	.40	.58	.48	15.00	13.08	1
12	2975	46375	9.65	6.81	10.25	8.69	1.08	2.70	2.38	38.92	34.12	3
13	3025	46375	9.65	8.49	14.01	11.54	1.40	3.27	2.18	70.95	63.38	6
14	3075	46375	9.65	.34	1.24	.83	.27	.39	.32	16.50	14.30	1
15	2925	46325	9.65	.04	.40	.21	.22	.35	.30	11.88	10.37	1
16	2975	46325	9.65	58.12	66.64	62.83	3.74	5.43	5.57	93.07	81.01	8
17	3025	46325	9.65	7.88	10.86	9.55	1.02	1.67	1.35	46.06	40.43	4
18	3075	46325	9.65	.04	.38	.21	.12	.22	.17	11.11	9.70	1
19	3150	46350	38.60	.06	.14	.10	.06	.06	.06	4.98	4.30	

TABLE 16 SUMMARY OF TOTAL SOURCE EMISSIONS BY
R PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY AREA

1967 (TONS/DAY)

VG.	SUM.	PART. WIN.	AVG.	SUM.	CO WIN.	AVG.	SUM.	HC WIN.	AVG.	SUM.	NO_x WIN.	AVG.
00	0.00	0.00	0.00	.57	.49	0.53	0.07	0.06	0.07	0.03	0.04	0.03
46	.06	.31	.26	15.45	13.36	14.34	2.12	1.84	1.97	1.01	1.50	1.26
44	1.38	2.02	1.91	41.15	36.14	38.54	4.11	4.59	4.82	2.57	3.75	3.16
48	.30	.47	.38	28.19	24.50	26.22	3.56	3.13	3.32	1.60	1.69	1.63
26	.15	.22	.19	11.92	10.35	11.07	1.61	1.41	1.50	.78	.87	.81
23	.16	.23	.19	14.03	12.18	13.02	1.91	1.69	1.78	.90	.93	.91
03	.64	.82	.73	37.05	32.09	34.41	5.41	4.71	5.04	3.17	3.49	3.30
74	1.16	1.77	1.46	49.48	44.16	47.08	6.35	5.65	5.97	4.51	5.30	4.85
87	.18	.23	.20	7.04	6.10	6.54	.96	.84	.89	.76	.92	.86
.77	.11	.19	.15	7.80	6.75	7.24	1.13	.98	1.05	.62	.83	.74
,64	.40	.58	.48	15.00	13.08	13.97	1.88	1.65	1.75	.85	1.07	.94
69	1.08	2.70	2.38	38.92	34.12	36.41	5.25	4.75	4.98	3.75	4.64	4.24
54	1.40	3.27	2.18	70.95	63.38	66.74	7.61	7.08	7.29	4.35	5.98	5.34
.83	.27	.39	.32	16.50	14.30	15.32	2.06	1.81	1.93	1.06	1.06	1.14
.21	.22	.35	.30	11.88	10.37	11.07	1.50	1.31	1.40	.68	.70	.68
2.83	3.74	5.43	5.57	93.07	81.01	87.09	10.27	9.39	9.79	21.02	22.93	21.85
9.55	1.02	1.67	1.35	46.06	40.43	43.02	5.10	4.59	4.82	3.63	4.28	3.96
.21	.12	.22	.17	11.11	9.70	10.36	1.39	1.22	1.30	.63	.66	.63
.10	.06	.06	.06	4.98	4.30	4.62	.73	.63	.68	.36	.33	.37

TABLE 16 SUMMARY OF TOTAL SOURCE EMISSIONS BY GRID FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY

1967 (TONS/DAY)

Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	Area (sq mi)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	CO AVG.
20	2850	46250	38.60	.05	.34	.19	.14	.18	.16	9.79	8.47	9.09
21	2925	45275	9.65	.04	.41	.22	.14	.21	.17	11.75	10.21	10.93
22	2975	46275	9.65	8.38	12.54	10.53	3.31	4.84	3.85	83.00	70.91	75.56
23	3025	46275	9.65	6.78	9.24	8.03	2.63	3.20	2.91	76.21	65.39	70.94
24	3075	46275	9.65	.09	.75	.40	.25	.37	.31	17.94	15.64	16.70
25	2925	46225	9.65	.07	.66	.36	.23	.33	.28	18.83	16.34	17.49
26	2975	46225	9.65	2.13	4.48	3.44	.87	1.22	1.04	49.74	45.51	47.48
27	3025	46225	9.65	.11	.44	.27	.26	.35	.30	24.78	21.53	23.04
28	3075	46225	9.65	7.64	8.24	7.93	.74	.86	.80	17.84	15.54	16.63
29	3150	46250	38.60	.15	1.45	.82	.46	.71	.57	24.73	21.59	23.05
30	3250	46250	38.60	64.29	66.27	65.27	2.40	2.73	2.55	12.56	10.96	13.65
31	3350	46250	38.60	.08	1.84	.95	.46	.73	.60	13.33	11.91	12.64
32	3450	46250	38.60	.01	.33	.17	.07	.14	.10	2.56	2.28	2.40
33	2850	46150	38.60	.11	.89	.50	.26	.36	.31	19.92	17.32	18.52
34	2950	46150	38.60	.52	2.70	1.63	.79	1.30	1.04	69.27	60.29	64.46
35	3050	46150	38.60	.15	1.02	.58	.37	.58	.47	34.46	29.95	32.05
36	3150	46150	38.60	2.89	4.93	4.13	.82	1.14	.98	20.97	18.41	19.60
37	3225	46175	9.65	54.53	56.15	55.34	24.33	24.88	24.58	22.90	20.43	21.64

ABLE 16 SUMMARY OF TOTAL SOURCE EMISSIONS BY
OR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY AREA

1967 (TONS/DAY)

PART.			CO			HC			NO_x		
SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.
.14	.18	.16	9.79	8.47	9.09	1.42	1.24	1.32	.72	.74	.72
.14	.21	.17	11.75	10.21	10.93	1.47	1.38	1.37	.68	.78	.75
3.31	4.84	3.85	83.00	70.91	75.56	9.87	8.86	9.34	5.85	6.70	6.24
2.63	3.20	2.91	76.21	65.39	70.94	8.21	7.31	7.72	4.49	3.98	4.70
.25	.37	.31	17.94	15.64	16.70	2.43	2.12	2.26	1.20	1.54	1.36
.23	.33	.28	18.83	16.34	17.49	2.36	2.06	2.20	1.06	1.17	1.11
.87	1.22	1.04	49.74	45.51	47.48	7.61	7.12	7.34	3.31	3.75	3.54
.26	.35	.30	24.78	21.53	23.04	3.12	2.72	2.91	1.40	1.45	1.41
.74	.86	.80	17.84	15.54	16.63	2.46	2.17	2.30	2.75	2.96	2.84
.46	.71	.57	24.73	21.59	23.05	3.59	3.28	3.17	1.84	2.03	1.92
2.40	2.73	2.55	12.56	10.96	13.65	2.60	2.46	2.51	20.23	20.46	20.33
.46	.73	.60	13.33	11.91	12.64	1.50	2.14	1.71	1.09	1.25	1.17
.07	.14	.10	2.56	2.28	2.40	.35	.32	.33	.19	.27	.23
.26	.36	.31	19.92	17.32	18.52	2.91	2.55	2.72	1.45	1.54	1.49
.79	1.30	1.04	69.27	60.29	64.46	8.74	7.68	8.17	3.99	4.26	4.09
.37	.58	.47	34.46	29.95	32.05	4.35	3.81	4.06	1.95	2.22	2.05
.82	1.14	.98	20.97	18.41	19.60	2.71	2.36	2.57	1.92	2.29	1.83
24.33	24.88	24.58	22.90	20.43	21.64	3.27	2.94	3.13	41.61	42.21	41.86

TABLE 16 SUMMARY OF TOTAL SOURCE EMIS
GRID FOR PROVIDENCE, NEW BEDFORD & FALL RI

1967 (TONS/DAY)

Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	Area (sq mi)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WI
38	3275	46175	9.65	.05	.67	.35	.14	.27	.21	8.16	
39	3325	46175	9.65	.05	.50	.27	.33	.40	.37	10.37	
40	3375	46175	9.65	.10	2.03	1.06	.42	.85	.63	23.66	2
41	3425	46175	9.65	.03	.48	.25	.10	.21	.16	8.03	
42	3475	46175	9.65	0.00	.74	.37	.17	.29	.33	1.65	
43	3550	46150	38.60	.03	1.75	.88	.28	.66	.46	4.76	
44	3550	46250	38.60	0.00	.46	.23	.07	.15	.11	1.56	
45	3225	46125	9.65	.02	.14	.08	.05	.05	.05	5.57	
46	3275	46125	9.65	.02	.12	.07	.05	.05	.06	5.77	
47	3325	46125	9.65	.05	.36	.20	.14	.17	.16	9.35	
48	3375	46125	9.65	18.12	20.31	19.41	1.00	1.81	1.39	31.03	2
49	3425	46125	9.65	2.56	4.25	3.52	.34	.72	.43	13.34	1
50	3475	46125	9.65	.01	.36	.18	.07	.13	.10	2.44	
51	2950	46050	38.60	.07	.54	.31	.21	.27	.24	14.43	1
52	3050	46050	38.60	.02	.28	.15	.09	.14	.12	6.86	
53	3150	46050	38.60	.12	.77	.46	.27	.49	.38	28.60	2
54	3250	46050	38.60	.01	.19	.10	.05	.07	.06	2.34	2
55	3350	46050	38.60	1.21	1.38	1.30	.15	.18	.16	7.67	
56	3450	46050	38.60	.14	.67	.46	.08	.11	.09	5.24	

TABLE 16 SUMMARY OF TOTAL SOURCE EMISSIONS BY GRID FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY AREA

1967 (TONS/DAY)

PART. AVG.	PART. SUM.	PART. WIN.	CO AVG.	CO SUM.	CO WIN.	HC AVG.	HC SUM.	HC WIN.	NO_x AVG.	NO_x SUM.	NO_x WIN.	NO_x AVG.
.35	.14	.27	.21	8.16	7.19	7.53	1.17	1.05	1.11	1.12	1.21	1.16
.27	.33	.40	.37	10.37	9.13	9.71	1.41	1.24	1.31	.83	.89	.85
1.06	.42	.85	.63	23.66	20.50	21.49	3.36	3.13	3.23	1.56	1.91	1.75
.25	.10	.21	.16	8.03	6.95	7.50	1.02	.90	.95	.47	.53	.49
.37	.17	.29	.33	1.65	1.59	1.61	.17	.19	.18	.16	.28	.22
.88	.28	.66	.46	4.76	4.53	4.63	.59	.63	.61	.44	1.10	.47
.23	.07	.15	.11	1.56	1.40	1.47	.19	.19	.19	.14	.28	.20
.08	.05	.05	.05	5.57	4.80	5.16	.76	.65	.70	.35	.33	.34
.07	.05	.05	.06	5.77	4.98	5.35	.79	.68	.73	.37	.32	.34
.20	.14	.17	.16	9.35	8.10	8.68	1.35	1.17	1.25	.69	.68	.68
19.41	1.00	1.81	1.39	31.03	27.56	29.11	4.03	4.31	4.95	7.11	8.10	7.60
3.52	.34	.72	.43	13.34	11.76	12.14	1.53	1.47	1.55	1.25	1.74	1.50
.18	.07	.13	.10	2.44	2.15	2.28	.31	.30	.30	.18	.27	.22
.31	.21	.27	.24	14.43	12.50	13.39	2.10	1.81	1.96	1.07	1.15	1.11
.15	.09	.14	.12	6.86	5.95	6,37	.85	.74	.79	.40	.44	.41
.46	.27	.49	.38	28.60	24.74	26.55	3.62	3.16	3.37	1.60	1.68	1.62
.10	.05	.07	.06	2.34	2.04	2.18	.32	.28	.30	.19	.24	.21
1.30	.15	.18	.16	7.67	6.62	7.10	1.13	.86	1.03	.78	.81	.80
.46	.08	.11	.09	5.24	4.54	4.86	.70	.60	.65	.38	.44	.41

TABLE 16 SUMMARY OF TOTAL SOURCE EMISSIONS BY GRID FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY

1967 (TONS/DAY)

Grid	Hor. Coor. (100m)	Vert. Coor. (100m)	Area (sq mi)	SO_x SUM.	SO_x WIN.	SO_x AVG.	PART. SUM.	PART. WIN.	PART. AVG.	CO SUM.	CO WIN.	CO AVG.
57	3950	45950	38.60	.02	.07	.04	.01	.05	.01	2.46	2.15	2.3
58	3050	45950	38.60	2.69	5.07	3.86	.50	.99	.74	27.36	24.06	24.1
59	3150	45950	38.60	.02	.40	.21	.09	.18	.13	6.78	5.96	6.3
60	2950	45850	38.60	.38	.54	.48	.11	.13	.12	8.50	7.33	7.8
61	2950	46650	38.60	.06	.36	.20	.17	.21	.18	12.68	10.99	11.7
62	3050	46650	38.60	.04	.42	.23	.14	.19	.17	10.31	8.94	9.5

TABLE 16 SUMMARY OF TOTAL SOURCE EMISSIONS BY
FOR PROVIDENCE, NEW BEDFORD & FALL RIVER STUDY AREA

1967 (TONS/DAY)

PART.			CO			HC			NO_x		
SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.	SUM.	WIN.	AVG.
.01	.05	.01	2.46	2.15	2.30	.30	.27	.28	.14	.14	.14
.50	.99	.74	27.36	24.06	24.14	3.10	2.84	2.96	2.15	2.68	2.39
.09	.18	.13	6.78	5.96	6.34	.85	.75	.79	.40	.47	.43
.11	.13	.12	8.50	7.33	7.88	1.16	1.00	1.08	.61	.64	.62
.17	.21	.18	12.68	10.99	11.78	1.72	1.50	1.60	.84	.94	.88
.14	.19	.17	10.31	8.94	9.57	1.39	1.21	1.29	.68	.73	.70

EMISSION DENSITIES BY GRID

Emission densities on a grid basis were obtained by summing the annual area and point source emissions for each grid. This total, divided by the grid area, gives an emission density in tons per square mile per average day. Figures 4 through 8 present the emission density maps for the five surveyed pollutants. It is difficult to make any valid conclusions from the emission density maps alone. For this reason when they are analyzed, the detailed map of the Study Area and the point source location map should also be considered.

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